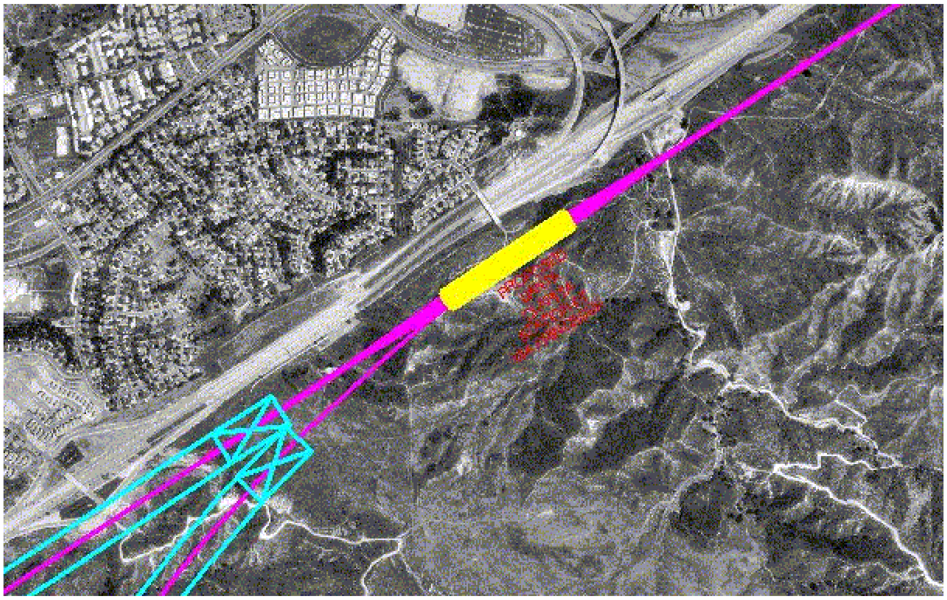


**Figure S.2-9 Santa Clarita Station Option 4, Via Princessa**

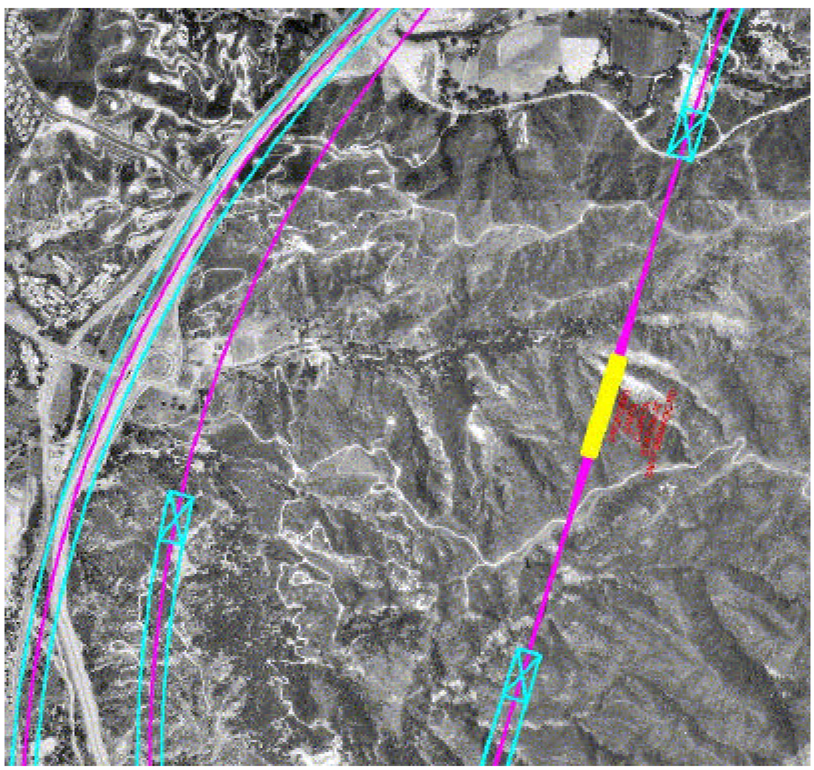


**Figure S.2-10 Santa Clarita Station Option 5, San Fernando Road/SR-14**

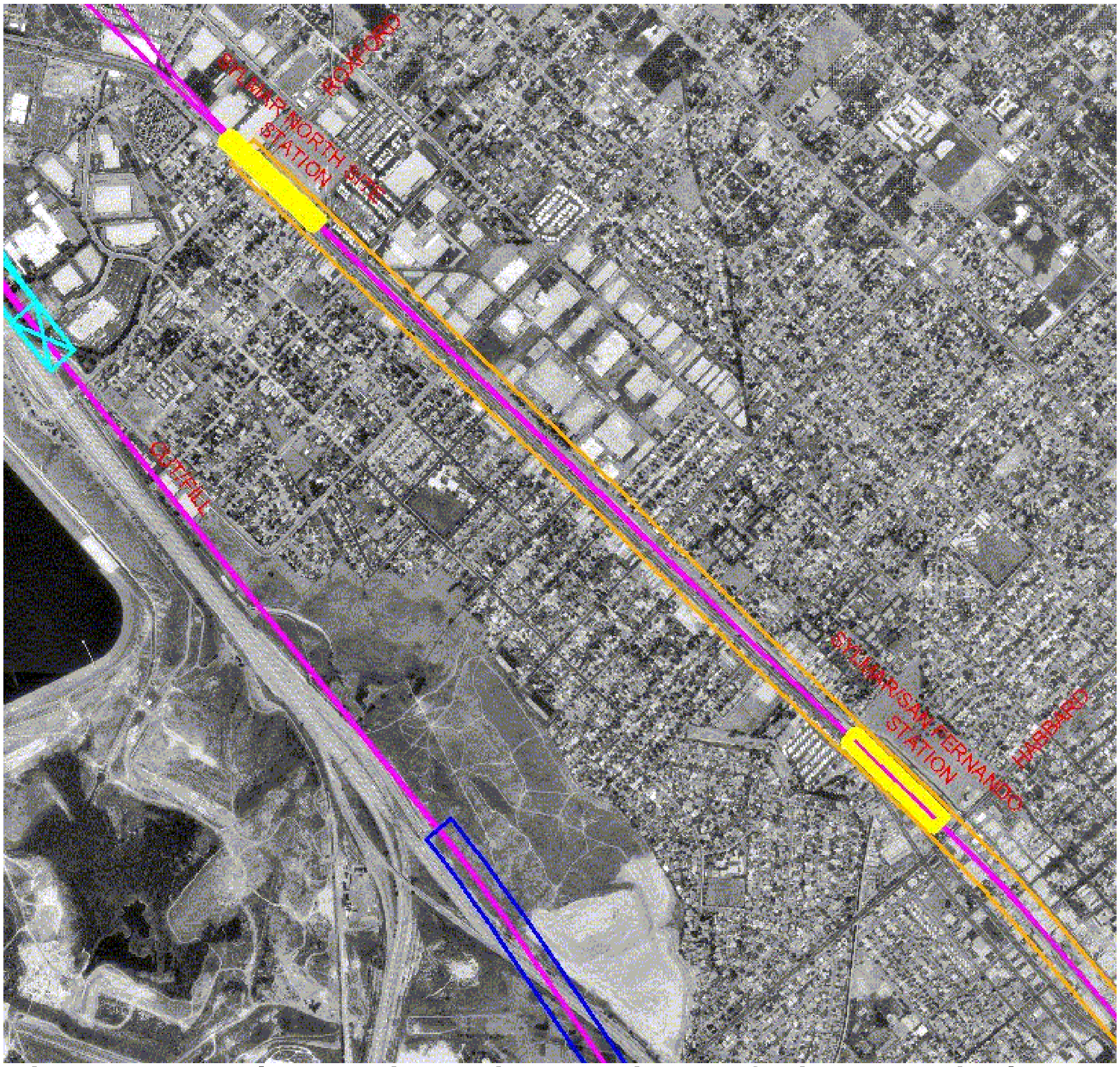



**Figure S.2-11 Sylmar Station Options 1 and 2, Roxford Street and Sylmar Metrolink Station.**

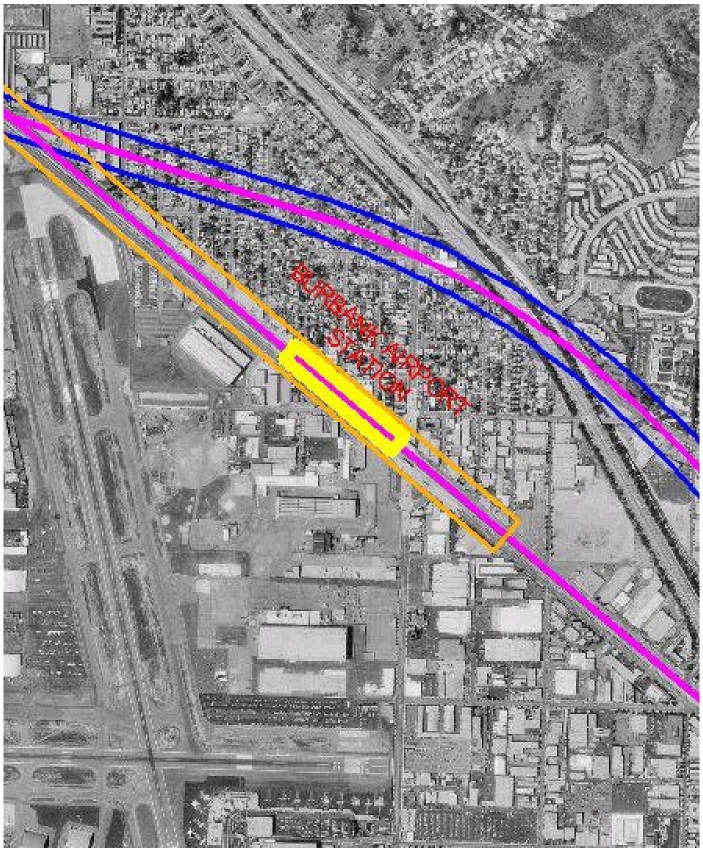



**Figure S.2- 12 Burbank Station Option 1, Burbank Airport.**

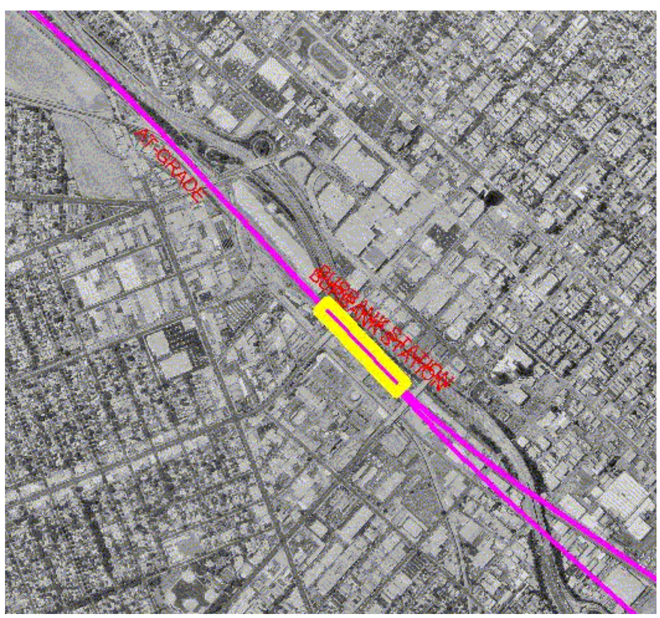



**Figure S.2-13 Burbank Station Option 2, Burbank Metrolink Station.**

location on a highly constrained site between I-5 and a flood control channel. A multi-level station structure with a parking garage would be necessary. However, the Metrolink Station is an existing focal point for local bus service, would allow for transfers from Metrolink service from points both north and west, would provide shuttle service to Burbank Airport and would be feasible with all three Sylmar-to-Los Angeles alignment options.

The Burbank Airport location would require a below-grade station since the alignment is in trench to traverse the clear zone of the Airport's north-south runway. It would incur more potential environmental justice impacts (due to the proximity of a minority neighborhood and elementary school), but would be closer to the Airport and could be integrated into Airport plans. Metrolink and Amtrak trips from points west would, however, require a shuttle for transfers from the Metrolink/Amtrak station on the south side of the Airport to the high-speed train station.

Los Angeles **(Figures S.2-14 and S.2-15)**:

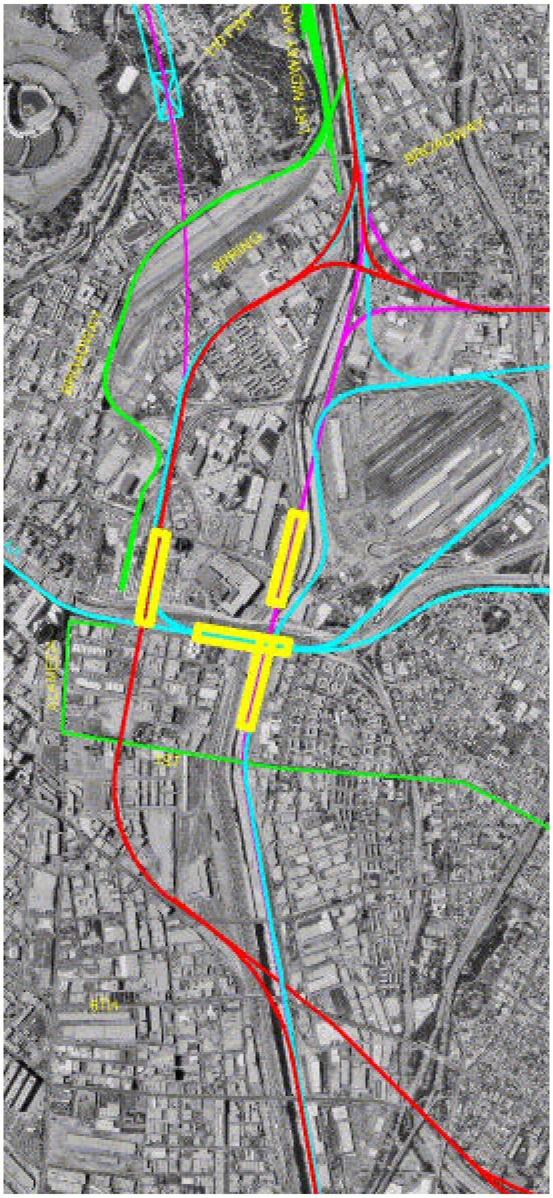
- Station Location Option 1 – Existing Union Station: Includes run through tracks to the south.
- Station Location Option 2 – Union Station South (Through): South of SR-101, straddling LA River; could be combined with Option 4.
- Station Location Option 3 – Union Station South (Stub): South of SR-101, between Alameda Street and LA River; can be combined with Option 4.
- Station Location Option 4 – LA River West: On the west bank of LA River connected to existing Union Station Complex by ancillary service/parking facilities/pedestrian concourse parallel to and south of SR-101; can be combined with Option 2 or 3 using an L-shaped platform layout.
- Station Location Option 5 – LA River East: On the east bank of the LA River north of SR-101, at MTA bus yard.
- Station Location Option 6 – Cornfield Site: Former rail yard sought by the Environmental Defense Fund for park use.

The selection of a Los Angeles station site is highly dependent upon the selection of alignments for connections to the LOSSAN and Inland Empire regions. Because of the high density of development in the downtown Los Angeles area, some Los Angeles station locations would not be able to connect with certain alignment options.

Station location Option 1, existing Union Station, has the best connectivity to other transportation modes and avoids river impacts. However, this station location option includes tracks crossing major development parcels in Little Tokyo and could also require double decking of tracks to provide for increased Metrolink operations and MTA transit improvements. Major new development is also planned for the immediate area by Catellus. Option 1 works well with north-south movements through downtown Los Angeles; connections with the UPRR/El Monte alignment would require stub end operations. Options 4 and 5, LA River East and West, are configured to work with a more direct north-south track that avoids the curves necessary to access the existing Union Station complex. Of these two, the LA River East, Option 5, is more favorable since it is more compatible with development and results in lower costs. Options 4 and 5 would both require stub end operations for connections with the UPRR/El Monte alignment. However, Option 5 could be combined in an L-shape with either station Option 2 or 3 to provide better rail connectivity. Option 4, the LA River West, would displace an existing MTA bus yard being considered as a maintenance yard site for the Eastside LRT Extension. The location of Option 4, with the County Jail complex and law enforcement center between the site and Patsouras Transit Plaza, makes a pedestrian connection to other modes of transportation extremely problematic.

The Union Station South (Stub) site, Option 3 is somewhat less compatible with local land use plans than the Union Station South (Through) site, Option 2, because it may conflict with the proposed Eastside LRT Extension. It also moves the station to a location more sensitive for cultural/historic resources. Another concern is that, with the exception of any LAX to Inland Empire or San Diego connections, Option 3 would not permit through movements of trains. Since it would allow through movements of trains,

**Figure S.2-14 Union Station Options 1, 2, 4 and 5, Existing Union Station, Union Station South (Through), LA River West and LA River East.**



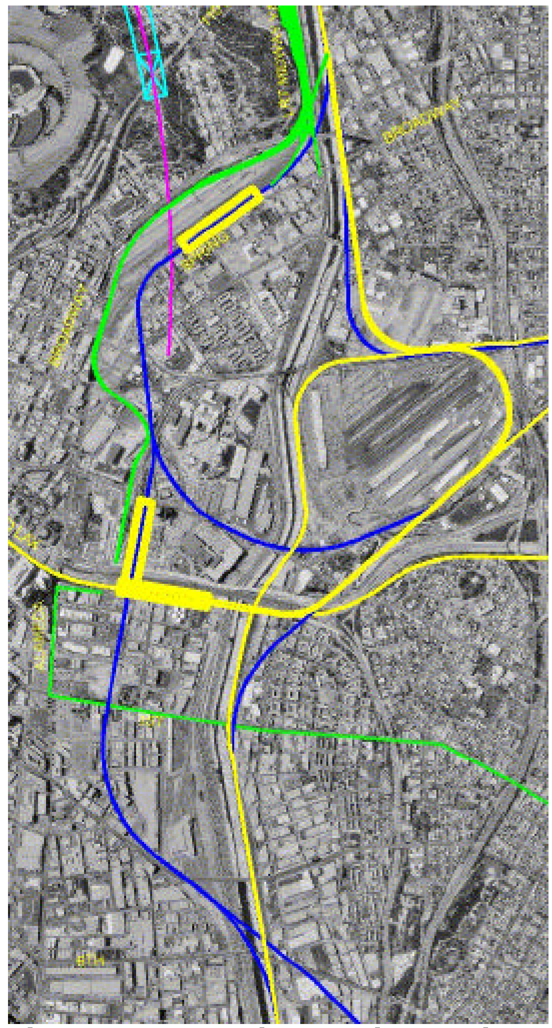




**Figure S.2-15 Union Station Options 1, 3, and 6, Existing Union Station, Union Station South (Stub) and Cornfield.**

Option 2 is the best station location for connections to the UPRR/El Monte alignment to the Inland Empire. However, Option 2 requires construction across the LA River, significant aerial structures and loop connections to the south if through tracks are not constructed out of existing Union Station. Option 6, the Cornfield site has the lowest connectivity, slow approach speeds, does not connect to Sylmar to LA alignments 2 and 3, has congested approaches from the standpoint of railroad operations and topography, significant aerial structure requirements, and poor arterial access. It also suffers from a fatal flaw because it is located on a controversial site proposed for park development and included in the LA River Greenbelt Planning effort.

**Table S.1-1**
**Bakersfield-to-Los Angeles – High-Speed Train Alignment Attainment of Objectives**
**Bakersfield-to-Sylmar Segment**

| Objective | Alignment Option 1<br>I-5 Alignment | Alignment Option 1A<br>I-5 via Comanche Pt. | Alignment Option 2<br>Soledad Cn./SR-58 | Alignment Option 2A<br>SR-14/SR-58 |
|---|---|---|---|---|
| Maximize Ridership/Revenue Potential | 2.5%: **5** 3.5%: **5** | **5** | 2.5%: **4** 3.5%: **4** | **4** |
| Maximize Connectivity and Accessibility | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| Minimize Operating and Capital Costs | 2.5%: **1** 3.5%: **3** | **2** | 2.5%: **2** 3.5%: **5** | **2** |
| Maximize Compatibility with Existing and Planned Development | 2.5%: **3** 3.5%: **2** | **3** | 2.5%: **3** 3.5%: **3** | **3** |
| Minimize Impacts to Natural Resources | 2.5%: **3** 3.5%: **2** | **3** | 2.5%: **3** 3.5%: **2** | **3** |
| Minimize Impacts to Social and Economic Resources | 2.5%: **4** 3.5%: **4** | **4** | 2.5%: **3** 3.5%: **3** | **3** |
| Minimize Impacts to Cultural Resources | 2.5%: **5** 3.5%: **5** | **5** | 2.5%: **2** 3.5%: **3** | **2** |
| Maximize Avoidance of Areas with Geologic and Soils Constraints | 2.5%: **3** 3.5%: **4** | **3** | 2.5%: **4** 3.5%: **5** | **4** |
| Maximize Avoidance of Areas with Potential Hazardous Materials | 2.5%: **4** 3.5%: **4** | **4** | 2.5%: **3** 3.5%: **3** | **3** |

**1 2 3 4 5**
Least Favorable Most Favorable

Note: 2.5% - Attainment of objective for alignments with 2.5 percent maximum grade.
3.5% - Attainment of objective for alignments with 3.5 percent maximum grade.

**Table S.1-1 (Con't.)**
**Bakersfield-to-Los Angeles – High-Speed Train Alignment Attainment of Objectives**
**Bakersfield-to-Sylmar Segment (Con't.)**

| Objective | Alignment Option 3<br>Soledad Cn./SR-138 | Alignment Option 3A<br>SR-14 / SR-138 | Alignment Option 4<br>Soledad Cn./Aqueduct | Alignment Option 4A<br>SR-14/Aqueduct |
|---|---|---|---|---|
| Maximize Ridership/Revenue Potential | 4 | 4 | 4 | 4 |
| Maximize Connectivity and Accessibility | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| Minimize Operating and Capital Costs | 4 | 3 | 4 | 3 |
| Maximize Compatibility with Existing and Planned Development | 4 | 4 | 3 | 3 |
| Minimize Impacts to Natural Resources | 3 | 4 | 3 | 4 |
| Minimize Impacts to Social and Economic Resources | 4 | 4 | 4 | 4 |
| Minimize Impacts to Cultural Resources | 4 | 3 | 2 | 1 |
| Maximize Avoidance of Areas with Geologic and Soils Constraints | 3 | 3 | 2 | 2 |
| Maximize Avoidance of Areas with Potential Hazardous Materials | 2 | 4 | 2 | 4 |

**1 2 3 4 5**
Least Favorable Most Favorable

**Table S.1-1 (Con't.)**
**Bakersfield-to-Los Angeles – High-Speed Train Alignment Attainment of Objectives**
**Sylmar-to-Los Angeles Union Station Segment**

| Objective | Alignment Option 1 Metrolink/UPRR | Alignment Option 2 I-5 Fwy. | Alignment Option 3 Combined I-5/UPRR |
|---|---|---|---|
| Maximize Ridership/Revenue Potential | 2 | 4 | 3 |
| Maximize Connectivity and Accessibility | Not Applicable | Not Applicable | Not Applicable |
| Minimize Operating and Capital Costs | 4 | 2 | 3 |
| Maximize Compatibility with Existing and Planned Development | 4 | 1 | 3 |
| Minimize Impacts to Natural Resources | 5 | 4 | 4 |
| Minimize Impacts to Social and Economic Resources | 3 | 1 | 4 |
| Minimize Impacts to Cultural Resources | 3 | 3 | 3 |
| Maximize Avoidance of Areas with Geologic and Soils Constraints | 4 | 4 | 4 |
| Maximize Avoidance of Areas with Potential Hazardous Materials | 2 | 3 | 2 |

**1 2 3 4 5**
Least Favorable Most Favorable

**Table S.1-2**
**Bakersfield-to-Los Angeles – High-Speed Train Station Attainment of Objectives**
**Bakersfield-to-Sylmar Segment-Antelope Valley Station**

| Objective | Antelope Valley Station Option 1 Lancaster Metrolink Station | Antelope Valley Station Option 2 Palmdale Transportation Ctr. | Antelope Valley Station Option 3 Palmdale Blvd. |
|---|---|---|---|
| Maximize Ridership/Revenue Potential | 2 | 3 | 3 |
| Maximize Connectivity and Accessibility | 4 | 4 | 3 |
| Minimize Operating and Capital Costs | 5 | 5 | 5 |
| Maximize Compatibility with Existing and Planned Development | 4 | 3 | 3 |
| Minimize Impacts to Natural Resources | 5 | 4 | 4 |
| Minimize Impacts to Social and Economic Resources | 4 | 5 | 5 |
| Minimize Impacts to Cultural Resources | 5 | 5 | 4 |
| Maximize Avoidance of Areas with Geologic and Soils Constraints | 4 | 3 | 3 |
| Maximize Avoidance of Areas with Potential Hazardous Materials | 5 | 5 | 5 |

**1 2 3 4 5**
Least Favorable Most Favorable

**Table S.1-2 (Cont'd.)**
**Bakersfield-to-Los Angeles – High-Speed Train Station Attainment of Objectives**
**Bakersfield-to-Sylmar Segment-Santa Clarita Station**

| Objective | Santa Clarita Station Option 1 SR-126 / I-5 | Santa Clarita Station Option 2 Magic Mt. Pkwy. / I-5 | Santa Clarita Station Option 3 The Old Road / I-5 | Santa Clarita Station Option 4 Via Princessa / SR-14 | Santa Clarita Station Option 5 San Fernando Rd. / SR-14 |
|---|---|---|---|---|---|
| Maximize Ridership/Revenue Potential | 2 | 2 | 2 | 3 | 3 |
| Maximize Connectivity and Accessibility | 2 | 2 | 1 | 3 | 3 |
| Minimize Operating and Capital Costs | 3 | 3 | 2 | 3 | 2 |
| Maximize Compatibility with Existing and Planned Development | 3 | 5 | 2 | 3 | 2 |
| Minimize Impacts to Natural Resources | 4 | 5 | 4 | 4 | 3 |
| Minimize Impacts to Social and Economic Resources | 4 | 5 | 5 | 5 | 5 |
| Minimize Impacts to Cultural Resources | 4 | 4 | 3 | 4 | 3 |
| Maximize Avoidance of Areas with Geologic and Soils Constraints | 4 | 4 | 4 | 4 | 4 |
| Maximize Avoidance of Areas with Potential Hazardous Materials | 4 | 4 | 4 | 5 | 4 |

**1 2 3 4 5**
Least Favorable Most Favorable

**Table S.1-2 (Cont'd.)**
**Bakersfield-to-Los Angeles – High-Speed Train Station Attainment of Objectives**
**Bakersfield-to-Sylmar Segment-Sylmar/Burbank Station**

| Objective | Sylmar Station Option 1 Roxford Rd. | Sylmar Station Option 2 Sylmar Metrolink Sta. | Burbank Station Option 1 Burbank Airport | Burbank Station Option 2 Metrolink/Media City |
|---|---|---|---|---|
| Maximize Ridership/Revenue Potential | 5 | 5 | 5 | 5 |
| Maximize Connectivity and Accessibility | 3 | 5 | 4 | 4 |
| Minimize Operating and Capital Costs | 3 | 4 | 3 | 2 |
| Maximize Compatibility with Existing and Planned Development | 4 | 5 | 5 | 5 |
| Minimize Impacts to Natural Resources | 5 | 5 | 5 | 5 |
| Minimize Impacts to Social and Economic Resources | 4 | 3 | 3 | 4 |
| Minimize Impacts to Cultural Resources | 5 | 5 | 5 | 5 |
| Maximize Avoidance of Areas with Geologic and Soils Constraints | 3 | 3 | 4 | 4 |
| Maximize Avoidance of Areas with Potential Hazardous Materials | 4 | 4 | 4 | 4 |

**1 2 3 4 5**
Least Favorable Most Favorable

**Table S.1-2 (Cont'd.)**
**Bakersfield-to-Los Angeles – High-Speed Train Station Attainment of Objectives**
**Bakersfield-to-Sylmar Segment-Los Angeles Union Station**

| Objective | Los Angeles Union Station Option 1 Existing Union Station | Los Angeles Union Station Option 2 Union Sta. South (Thru) | Los Angeles Union Station Option 3 Union Sta. South (Stub) |
|---|---|---|---|
| Maximize Ridership/Revenue Potential | 5 | 5 | 5 |
| Maximize Connectivity and Accessibility | 5 | 4 | 4 |
| Minimize Operating and Capital Costs | 3 | 2 | 2 |
| Maximize Compatibility with Existing and Planned Development | 5 | 4 | 5 |
| Minimize Impacts to Natural Resources | 5 | 4 | 4 |
| Minimize Impacts to Social and Economic Resources | 4 | 4 | 4 |
| Minimize Impacts to Cultural Resources | 3 | 2 | 3 |
| Maximize Avoidance of Areas with Geologic and Soils Constraints | 4 | 4 | 4 |
| Maximize Avoidance of Areas with Potential Hazardous Materials | 4 | 4 | 4 |

**1 2 3 4 5**
Least Favorable Most Favorable

**Table S.1-2 (Cont'd.)**
**Bakersfield-to-Los Angeles – High-Speed Train Station Attainment of Objectives**

## Bakersfield-to-Sylmar Segment-Los Angeles Union Station

| Objective | Los Angeles Union Station Option 4 LA River West | Los Angeles Union Station Option 5 LA River East | Los Angeles Union Station Option 6 Cornfield Site |
|---|---|---|---|
| Maximize Ridership/Revenue Potential | 5 | 5 | 5 |
| Maximize Connectivity and Accessibility | 3 | 3 | 2 |
| Minimize Operating and Capital Costs | 3 | 4 | 2 |
| Maximize Compatibility with Existing and Planned Development | 4 | 5 | 4 |
| Minimize Impacts to Natural Resources | 4 | 4 | 5 |
| Minimize Impacts to Social and Economic Resources | 4 | 4 | 4 |
| Minimize Impacts to Cultural Resources | 3 | 3 | 3 |
| Maximize Avoidance of Areas with Geologic and Soils Constraints | 4 | 4 | 4 |
| Maximize Avoidance of Areas with Potential Hazardous Materials | 4 | 4 | 4 |

**1 2 3 4 5**
Least Favorable Most Favorable

# 1.0 INTRODUCTION

Since 1992, extensive information has been gathered and preliminary evaluation has been completed concerning the potential environmental effects associated with numerous high-speed train corridor alternatives throughout California. From feasibility studies through conceptual design, a variety of technical studies have been undertaken to address the engineering, operational, financial, ridership, and environmental aspects of such a system. The findings of these studies concluded that California would benefit substantially from high-speed train transportation. Because of the anticipated benefits and the proven need for additional transportation options, the further evaluation of a high-speed train system is seen as the next logical step in the development of California's transportation infrastructure.

The current stage of project development for a statewide high-speed train system is designed to further optimize alignments, avoid/minimize environmental impacts, and develop a more accurate cost figure based on a more refined level of engineering and environmental analysis. As such, the California High-Speed Rail Authority (Authority) has initiated a formal environmental clearance process through the preparation of a state program-level Environmental Impact Report (EIR) and a federal Tier I Environmental Impact Statement (EIS) or Program EIR/EIS. The Program EIR/EIS will satisfy the requirements of the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) for the first tier of environmental review. As part of the Program EIR/EIS, a number of alternatives are being evaluated including a No-Build Alternative, High-Speed Train Alternative(s), and Other Modal Alternatives (aviation, highway, and conventional passenger rail).

To accomplish this program environmental effort, the Authority has divided the state study area into five regions: Bay Area-to-Merced, Sacramento-to-Bakersfield, Bakersfield-to-Los Angeles, Los Angeles-Orange County-San Diego, and Los Angeles-to-San Diego via the Inland Empire.

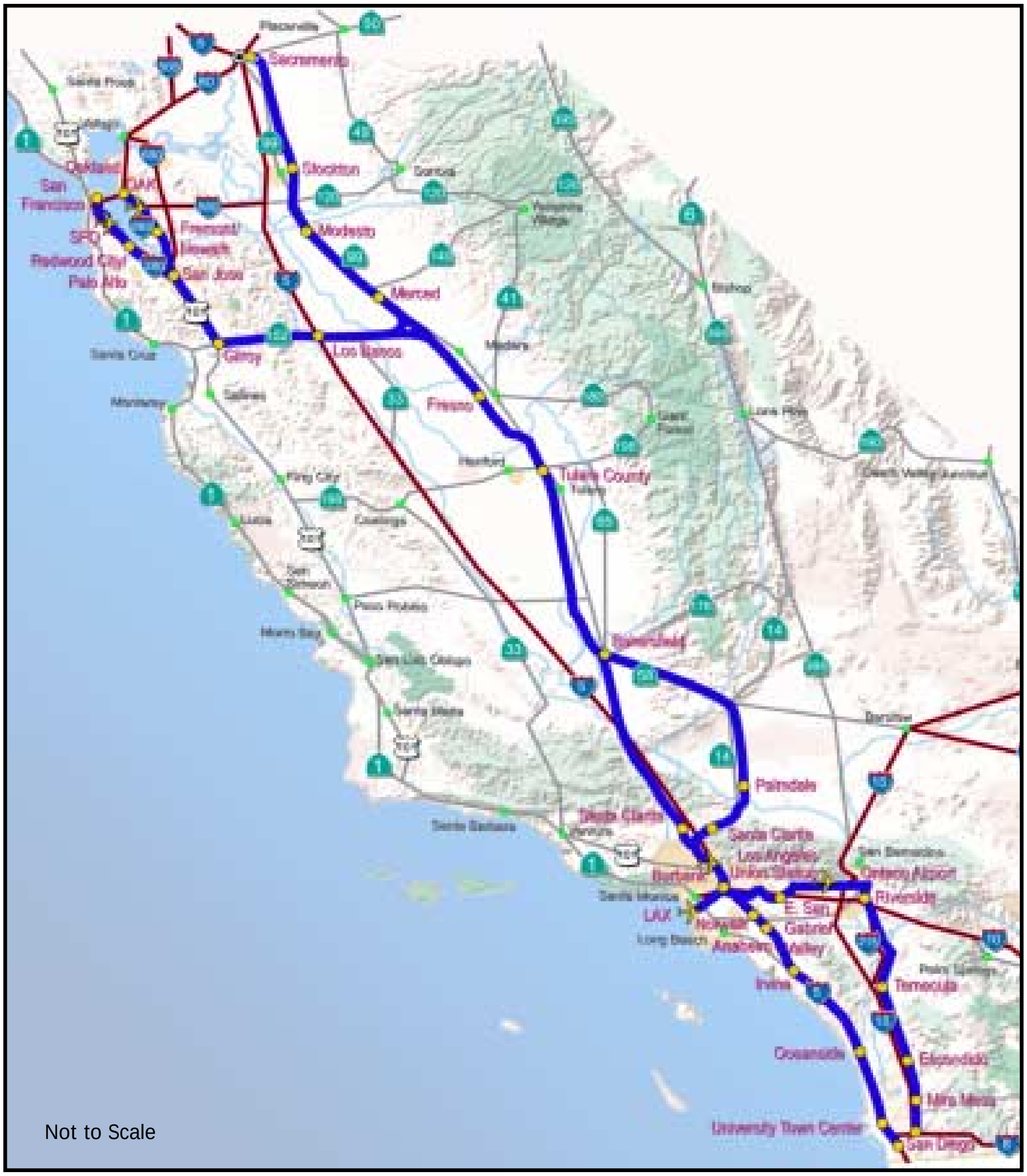
## 1.1 PURPOSE

Within the High-Speed Train Alternative, there is a range of high-speed train alignment and station location options to be considered. The majority of these options have been evaluated in prior studies and have been presented to the previous California Intercity High-Speed Rail Commission and the current Authority. Some corridors were carried forward for further consideration while others have been removed from further study based on their relative merit and viability for potential implementation as part of a statewide high-speed train system. Those corridors that have been carried forward are illustrated in Figure 1.1-1 and documented in the Authority's June 2000, *Final Business Plan*[1] and the December 1999, *California High-Speed Rail Corridor Evaluation*.[2]

The purpose of the Alignment Screening Evaluation is to consider all reasonable and practical alignment and station options at a consistent level of analysis and focus the program environmental analysis on the most viable of these alignment and station options. The initial set of alignments and station locations was identified by reviewing prior Commission and Authority studies, through meetings with elected officials, and through the environmental scoping process.

[1] California High-Speed Rail Authority. *Building a High-Speed Train System for California, Final Business Plan*, June 2000.
[2] Parsons Brinckerhoff. *California High-Speed Rail Corridor Evaluation.* Prepared for California High-Speed Rail Authority, December 1999.

**Figure 1.1-1**
**Recommended Corridors to be Studied in the Environmental Process**




Source: California High-Speed Rail Authority. *Building a High-Speed Train System for California, Final Business Plan,* 2000.

The results of this screening process and information differentiating the alignment and station options are documented herein for the Bakersfield-to-Los Angeles region. Similar reports are being prepared for the other four regions. Each of the region screening reports will be summarized into a Statewide High-Speed Train Alignments/Stations Screening Evaluation that will be presented to the Authority Board. Based on recommendations by the Authority staff, the Board will select alignments and stations to be carried forward for more detailed analysis in the Program EIR/EIS.

## 1.2 BACKGROUND

The California Intercity High-Speed Rail Commission was established in 1993 by Senate Concurrent Resolution (SCR) 6 to investigate the feasibility of a high-speed train system for California, specifically, a system connecting the San Francisco Bay Area, Los Angeles, San Diego, and Sacramento. To address this question of feasibility, the Commission successfully conducted a series of technical studies encompassing ridership and revenue forecasts; economic impact and benefit cost analyses; institutional and financing options; corridor evaluation and environmental impacts and constraints analyses; and preliminary engineering feasibility studies. Based on these studies, the Commission determined that a high-speed train system is technically, environmentally, and economically feasible and set forth recommendations for the technology, corridors, financing, and operation for this system.

The California High-Speed Rail Authority was created by the state Legislature in 1996 (Chapter 796 of the Statutes of 1996 — Senate Bill 1420, Kopp and Costa) to be an implementing agency that would construct, operate, and fund a statewide, intercity high-speed passenger rail system. Based on recently completed studies, evaluations, and previous analysis, the Authority has developed a plan to implement a statewide high-speed train system in California. The current proposal is presented in the Authority's *Business Plan*. The plan describes a 700-mile (1,126-kilometer) -long system capable of speeds in excess of 200 miles per hour (mph) (320 kilometers per hour [km/h]) on dedicated, fully grade-separated tracks with state-of-the-art safety, signaling, and automated train control systems. The system would serve the major metropolitan centers of California.

Beginning in 1992, several studies pertaining to planning, engineering, ridership/revenue, financing, and economic impact have been completed under the direction of the California Department of Transportation (Caltrans), the past Commission, and the current Authority. These studies provided information that formed the basis of the decisions made and direction of the continuing studies. Because of the nature of this initial screening evaluation, this report primarily references the three planning and engineering studies that have been completed. While these studies differed in terms of their specific scopes of work, they all shared the common focus of identifying potential corridors for the implementation of high-speed train lines and evaluating the feasibility and viability of these corridors. Analysis of environmental constraints through use of existing databases and identification of potential impacts were key components of these studies. The studies were completed in consecutive order, allowing for each subsequent study to benefit from, and build on, the work completed in the prior study. Each of the three studies is described in detail in the *California High-Speed Rail Corridor Evaluation - Environmental Summary Report.*[3] Public involvement was an important part of the feasibility studies. The public was updated on the study progress and key decision points with newsletters and access to the Authority's website.

### 1.2.1 Los Angeles – Bakersfield Preliminary Engineering Feasibility Study (1994)[4]

Completed in 1994, this study analyzed the feasibility of constructing a high-speed train crossing of the Tehachapi Mountains in Southern California. After considering a broad range of alternative alignments, the study focused on the most viable routes. Two main corridors between Los Angeles and Bakersfield were considered feasible in terms of cost, travel time, and environmental impact: I-5 Grapevine and Palmdale-Mojave. The corridors studied traversed a variety of terrain (urban development, mountains, valley floor, etc.), allowing the engineering and costing analyses to be applicable to other portions of the

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[3] Parsons Brinckerhoff. *California High-Speed Rail Corridor Evaluation - Environmental Summary.* Prepared for California High-Speed Rail Authority, April 2000.

[4] Parsons Brinckerhoff. *Los Angeles - Bakersfield High-Speed Ground Transportation Preliminary Engineering Feasibility Study Final Report*. Prepared for Caltrans, December 1994.

state. Because of this applicability, work performed for the Los Angeles–Bakersfield study provided an important foundation for the subsequent statewide corridor evaluation studies.

### 1.2.2 California High-Speed Rail Corridor Evaluation and Environmental Constraints Analysis (1996)[5]

This study was conducted in three phases and was completed in 1996. The first phase defined the most promising corridor alignments for linking the San Francisco Bay Area and Los Angeles. During the second phase, these alternative corridors between Los Angeles and the Bay Area were examined in more detail. The third phase examined potential high-speed train system extensions to Sacramento, San Bernardino/Riverside, Orange County, and San Diego. The study identified station locations and estimated travel times; developed construction, operation, and maintenance cost estimates; analyzed environmental constraints and possible mitigation measures; and, in an iterative process with the Ridership Study, developed a conceptual operating plan. The corridors recommended for further study in Phases 2 and 3 were refined in the corridor evaluation studies completed by the Authority.

### 1.2.3 California High-Speed Rail Corridor Evaluation (2000)[6]

In September of 1998, the Authority commissioned a *Corridor Evaluation* study to assess and evaluate the viability of various corridors throughout the state for implementation as part of a statewide high-speed train system. To address new issues raised by local and regional agencies, further corridor investigations and evaluations were conducted in several areas of the State and compared in the context of updated information on previously studied routes. The Authority was mandated to move forward in a manner that was consistent with, and continued the work of the Commission. Using the Commission's recommended corridors as a foundation, potential corridors were further evaluated on the basis of capital, operating and maintenance costs; travel times; and engineering, operational, and environmental constraints. The corridors were compared and evaluated on a regional basis and as part of a statewide system. From this study, the Authority identified corridors to be included in the current stage of project development as part of the Program EIR/EIS.

[5] Parsons Brinckerhoff. *California High-Speed Rail Corridor Evaluation and Environmental Constraints Analysis.* Prepared for California Intercity High-Speed Rail Commission, June 1996.
[6] Parsons Brinckerhoff. *California High-Speed Rail Corridor Evaluation.* Prepared for California High-Speed Rail Authority, December 1999.

# 2.0 PARAMETERS/ASSUMPTIONS AND EVALUATION METHODOLOGY

Unless otherwise noted, the objectives, parameters, criteria, and methodologies described in this report are consistent with those applied in previous California high-speed train studies and documented in the *California High-Speed Train Program EIR/EIS*, *Task 1.5.2 – High-Speed Train Alignment/Station Screening Evaluation Methodology*.[7]

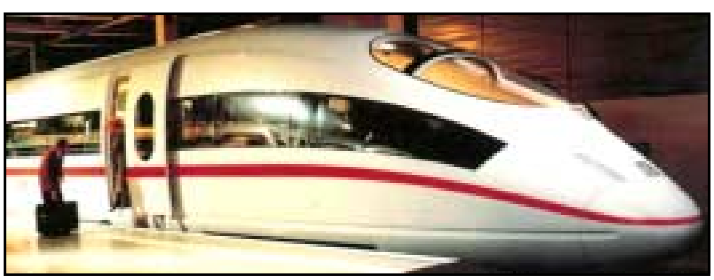
## 2.1 PARAMETERS/ASSUMPTIONS

High-speed train alignment and station options were developed through consistent application of system, engineering, and operating parameters as described in Task 1.5.2. The parameters and assumptions applied are consistent with those applied in previous planning and engineering studies and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed rail systems, and recommendations of VHS and maglev manufacturers.

### 2.1.1 Statewide Parameters/Assumptions

The design, cost, and performance parameters used in developing the alignment and station options are based on two technology groups (classified by speed) (Figure 2.1.1). The Very High-Speed (VHS) group includes trains capable of maximum operating speeds near 220 mph (350 km/h) utilizing steel-wheel-on-steel-rail technology. Requirements for a VHS system include a dedicated, fully grade-separated right-of-way with overhead catenary for electric propulsion. However, it is possible to integrate a VHS system into existing conventional rail lines in congested urban areas given resolution of certain equipment and operating compatibility issues. The magnetic levitation (maglev) group utilizes magnetic forces to lift and propel the train along a guideway and is designed for maximum operating speeds above that of VHS technology. A maglev system requires a dedicated guideway and may share right-of-way, but not track, with conventional train systems.

**Figure 2.1-1**
**VHS and Maglev Technology**



*VHS Train (Germany ICE)*

*Maglev (Transrapid)*

[7] Parsons Brinckerhoff. *California High-Speed Train Program EIR/EIS, Task 1.5.2 – High-Speed Train Alignments/Stations Screening Evaluation Methodology*. Prepared for California High-Speed Rail Authority, May 2001.

High-speed train system engineering design parameters used in developing the alignments were documented in Task 1.5.2 and include speeds, geometry, and clearances for both steel-wheel-on-steel-rail (VHS) and maglev high-speed train technologies. The parameters and criteria, summarized in Table 2.1-1, are consistent with previous California high-speed train studies and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed train systems, and recommendations of VHS and maglev manufacturers.

**Table 2.1-1**
**Summary of Engineering Design Parameters**

| Parameter | Very High-Speed | Maglev |
|---|---|---|
| **Double Track** | Full | Full |
| **Power Source** | Electric | Electric |
| **Grade Separations** | Full | Full |
| **Potential for Shared Use** | Yes | No |
| **Corridor Width**<br>❑ **Desirable**<br>❑ **Minimum** | <br>100 ft (30.4 m)<br>50 ft (15.2 m) | <br>100 ft (30.4 m)<br>50 ft (15.2 m) |
| **Top Speed** | 220 mph<br>(350 km/h) | 240 mph(1)<br>(385 km/h) |
| **Average Speed** | 125-155 mph<br>(200-250 km/h) | 145-175 mph<br>(230-280 km/h) |
| **Acceleration** | 0.4-1.3 mph/s(3)<br>(0.6-2.1 km/h/s(4)) | 1.1-1.9 mph/s<br>(1.8-3.2 km/h/s) |
| **Deceleration** | 1.2 mph/s<br>(1.9 km/h/s) | 1.8 mph/s<br>(2.9 km/h/s) |
| **Minimum Horizontal Radius** | 500-650 ft<br>(150-200 m) | 1,150 ft<br>(350 m) (2) |
| **Minimum Horizontal Radius**<br>(at top speed) | 15,600 ft @ 220 mph<br>(4,750 m @ 350 km/h) | 11,500 ft @ 240 mph<br>(3,500 m @ 385 km/h) |
| **Superelevation**<br>❑ **Actual (Ea)**<br>❑ **Unbalanced (Eu)** | <br>7 in (180 mm)<br>5 in (125 mm) | <br>16°<br>5° |
| **Grades**<br>❑ **Desirable Maximum**<br>❑ **Absolute Maximum** | <br>3.5%<br>5.0% | <br>NA<br>10.0% |
| **Minimum Vertical Radius**<br>Crest Curve (at top speed) | 157,500 ft @ 220 mph<br>(48,000 m @ 350 km/h) | 205,700 ft @ 240 mph<br>(62,700 m @ 385 km/h) |
| **Minimum Vertical Radius**<br>Sag Curve (at top speed) | 105,000 ft @ 220 mph<br>(32,000 m @ 350 km/h) | 137,100 ft @ 240 mph<br>(41,800 m @ 385 km/h) |
| **Horizontal Clearance**<br>(centerline of track to face of fixed object) | 10 ft 4 in @ 220 mph<br>(3.1 m @ 350 km/h) | 9 ft 5 in @ 240 mph<br>(2.8 m @ 385 km/h) |
| **Vertical Clearance**<br>(top of rail to face of fixed object) | 21 ft (6.4 m) | 12 ft 2 in (3.7 m) |
| **Track Centerline Spacing** | 15 ft 8 in @ 220 mph<br>(4.7 m @ 350 km/h) | 15 ft 9 in @ 240 mph<br>(4.8 m @ 385 km/h) |
| **Minimum Right-of-Way Requirements**<br>At-Grade/Cut-and-Fill/Retained Fill<br>Aerial Structure<br>Tunnel (Double Track)<br>Tunnel (Twin Single Track)<br>Trench/Box Section | <br>50 ft (15.2 m)<br>50 ft (15.2 m)<br>67 ft (20.4 m)<br>120 ft (36.6 m)<br>70 ft (21.3 m) | <br>47 ft (14.3 m)<br>49 ft (15 m)<br>67 ft (20.4 m)<br>120 ft (36.6 m)<br>73 ft (22.2 m) |
| **Minimum Station Platform Length** | 1,300 ft (400 m) | 1,300 ft (400 m) |
| **Minimum Station Platform Width** | 30 ft (9 m) | 30 ft (9 m) |

Notes: 1- Top Speed Defined in Federal Maglev Deployment Plan
2- Transrapid USA, 1998.
3- mph/s – miles per hour-second
4- km/h/s – kilometers per hour-second

Based on the minimum requirements listed in Table 2.1-1, three general right-of-way parameters were utilized for the screening evaluation: (1) a minimum right-of-way corridor of 50 feet (15.2 meters) was assumed in congested corridors; (2) a 100-foot (30.4-meter) corridor was assumed in less developed areas to allow for drainage, future expansion and maintenance needs; and (3) a wider corridor was assumed in variable terrain to allow for cut and fill slopes and tunnels.

The overall operations strategy and conceptual service parameters that were assumed for high-speed train service in California are documented in Task 1.5.2. Specific scheduling and operations modeling analysis is currently underway and will be used in future detailed engineering and environmental analyses in the next phase of this study.

### 2.1.2 Bakersfield-to-Los Angeles Parameter/Assumption Variances

The engineering assumptions used to evaluate the Bakersfield-to-Los Angeles corridor generally mirror those in Task 1.5.2. In some cases, however, the high-speed train system engineering design parameters developed for the statewide system were modified somewhat to better match local conditions encountered within the region, respond to recent development activity, improve system operations, avoid environmental impacts and concomitant mitigation requirements, reduce energy demand and lower maintenance costs.

A. CORRIDOR WIDTH

A corridor width of 50 feet was applied to the dense urban segment between Sylmar and Los Angeles Union Station. This minimum width reflects the intensive land use constraints extant in this corridor. A full 100-foot wide corridor was assumed for the segment between Bakersfield and Sylmar due to its less intensive suburban and rural character, and sections of mountainous terrain. No allowance was made for slope easements.

B. GRADES

Earlier studies of the Bakersfield-to-Los Angeles corridor aimed at minimizing the overall length of tunnels along their respective alignment alternatives. A series of vertical profile alternatives were developed using various gradients – from conventional (1.5 percent maximum) to aggressive (5 percent maximum for VHS) – with the dual goals of reducing tunnels through the Tehachapis and avoiding tunnel crossings of the two major faults (San Andreas and Garlock). A 3.5 percent gradient profile was used in developing alignments presented in the California High-Speed Rail Authority Final Business Plan (June 2000). Use of the 3.5 percent grade allowed tunneling along the Business Plan's I-5 and Antelope Valley alignments to be limited to a total of 28 miles (18 km) and 11 miles (7 km), respectively.

Grades of up to 3.5 percent have been employed in European high-speed train systems. The use of higher gradients; however, has largely been avoided due to loss in speed or increase in power consumption. The CTRL under construction in England, with a design speed of 280 kph, employs 2.5 percent grades without limit and limited 3 percent grades (600 meter maximum length). TGV's Paris to Marseille route, which opened most recently, features operating speeds of up to 330 kph and 6 km-long grades at up 3.5 percent. From Paris to Lyon along LGV Paris Sud-Est, which includes a vertical climb of approximately 450 meters, tunneling is completely avoided by constructing many short stretches of steeper gradient.

Due to the broad-reaching implications of gradient criteria within this region, significant consideration was given to the application of the desirable maximum grade along the alignment. Use of the 3.5 percent grade criterion set forth in the Business Plan results in a series of short tunnels and an overall reduction in tunneling length. The 2.5 percent-maximum grade alignments that were also considered in the current study would substantially increase total tunnel length, but would offer improved operating characteristics and lessened environmental impacts. While tunnel construction includes inherent construction issues, some additional challenges would be presented by the construction of a series of short tunnels, rather than fewer, longer tunnels. These issues are described in more detail below.

The most important factor in the approach to grades made by earlier studies was to avoid tunnels at fault crossings. The use of at least a 3.5 percent grade allows alignments along I-5 and SR-58 to be aboveground at crossings of the San Andreas Fault and the Garlock Fault, respectively. The southerly tunnel portal on the 3.5 percent I-5 alignment; however, is very close to the San Andreas fault zone, that significant seismic movement at the portal itself could be expected. Where a flatter grade is applied, seismic chambers would be required at fault crossings to allow train service to be restored after an earthquake event.

Evacuation routes must also be considered in the construction of tunnels. Longer, deeper tunnels that do not provide opportunities for escape along their length would require the construction of parallel evacuation routes. These parallel tunnels add significant cost to the alignment options through the Tehachapi Mountains.

### *Train Performance*

Long, steep gradients require additional power while reducing train speeds and operational capabilities. The German Peer Review prepared by DE Consult (December 2000) shows that train performance is compromised on long, sustained gradients. For gradients of 3.5 percent, the newest technology trainset can be expected to lose 50 percent of its 220 mph (350 kph) top speed over a length of 19 miles (30 km). While speed reduction is significant, the impacts on travel times would be fairly limited in crossing the Tehachapis because sustained grades are generally no longer than 9 miles (15 km) – only one additional minute of travel time would be expected to traverse a steeper 3.5 percent alignment as compared to a 2.5 percent maximum grade alignment.

On the downhill, however, steep grades can tax braking systems. Braking of high-speed trains is accomplished by a combination of wheel, pneumatic, and dynamic braking systems. At speeds up to 220 mph (350 kph), significant energy is required to slow the train. Additionally, on steep downgrades, the train's high kinetic energy can overheat braking systems or, in worst cases, cause heat stress to the railhead Specific speed instructions are required prior to down grade to properly employ brakes and to prevent runaway trains.

In addition to speed consequences, operation over steeper grades presents power implications. Sustained 3.5 percent grades demand higher power and tractive effort. The peer review by DE Consult indicates that trainsets with distributed power would be required to climb this gradient, even with speed losses described above. Earlier reports prepared by DE Consult and Parsons Brinckerhoff (Travel Time and Energy Usage Analysis and Results, December 1994) do not present specific comparisons of 2.5 percent versus 3.5 percent grades, but show that energy consumption increases 10 percent to 40 percent for uphill operation on 3.5 percent grade as compared to the downhill operation along the same alignment.

### *Tunnel Portal Effects*

Higher gradients, with shorter, but generally more, tunnels present operational issues related to tunnel portal effects. As high-speed vehicles enter tunnels, they create compression and expansion waves that run the length of the tunnel and back again at the speed of sound. These waves created by high-speed trains in smooth and long tunnels can cause pain to eardrums and can potentially shatter glass. Moreover, under unfavorable conditions, people living near-by tunnel portals could suffer from the noise and vibrations (phenomena designated as "sonic boom") caused by the transmission, in the surroundings of tunnels exits, of an impulsive spherical pressure wave. The later is called "micro-pressure wave"; it is created when the wavefront of the primary compression wave is reflected the first time it reaches the tunnel end. Such phenomena can result in less effective HST speeds-up or even, worse, in speed reductions. While no micro-pressure waves strong enough to result in a sonic boom have ever yet been recorded at tunnel exits in Europe in revenue service conditions, such an event is likely to happen soon as slab track technology starts to be applied to long tunnels across Europe.

A variety of methods have been employed to address pressure waves at tunnel portals. The intensity of acoustic waves can be minimized by applying speed restrictions, precluding the passing of trains within tunnels, modifying rolling stock, adopting an oversize tunnel cross-section, and/or incorporating pressure alleviation devices at portals and along tunnel lengths.

Proper portal design is critical to minimizing operational and comfort impacts at tunnel entrances. Flared shapes, elongated portals, and perforated entrance hoods serve to reduce aerodynamic effects. To diffuse air pressures, portals vary in length from 150 meters to 300 meters, dependent upon design.

Accommodations along tunnel length can be used to also improve aerodynamics. Porous dividing walls, cross-passages, and airshafts connected to the surface can help minimize pressure waves. The construction of a number of airshafts located at positions spread along the length of the tunnel can reduce pressure wave strengths; however, shaft sites require access for construction and future maintenance.

### *Construction Issues Related to Grade*

Tunnel construction can be significantly reduced by increasing profile gradient. Under the 3.5 percent grade alignments, tunnels are generally shorter and shallower, reducing the construction risks inherent to tunneling.

Conversely, multiple short tunnels mean that there would be more tunnel portals. Access for construction and operations would be required at each tunnel portal. Each portal results in a large area of disturbance to allow for construction of lengthy portal walls designed to minimize tunnel blast effects. Through the Tehachapi Crossing, portal areas are generally in remote and sensitive locations, where the construction of portals and related infrastructure will have significant impacts.

**Construction (top) and simulated completed tunnel portal (bottom) on Rome to Naples high-speed rail line in Italy.**

Multiple short tunnels also mean a requirement for more tunnel boring machines (TBMs) and TBM and equipment staging areas. The TBM must be reset at each portal, increasing mobilization costs and offsetting the efficiency that is achieved in a continuous TBM drive. Power must be brought in to start and run each TBM, with the peak power requirement needed to start the bore. This requires construction of substations and power lines to the portal site. These requirements result in further environmental impacts.

Grade and tunnel features of the Tehachapi crossing also have constructibility implications. The construction of the Bakersfield-to-Los Angeles alignment would generate significant spoil, resulting from both cut and tunneling through the mountains. A 7.0-meter diameter (single track) tunnel would produce 38,500 cubic meters of spoil for every kilometer of tunneling. The most effective method of removing and disposing of excavated soils would likely be by rail; however, conventional rail equipment cannot climb sustained grades in excess of 2.5 percent. If spoil cannot be removed by rail, it must be trucked or conveyored from the tunnel portal to the eventual disposal site. This would require use of access roads, conveyor routes and establishment of spoil disposal sites in the vicinity of the tunnel portal.

**Comparison of Grade Alternatives**

Given these considerations, in addition to the 3.5 percent maximum grade, vertical alignments over the Tehachapis with grades limited to 2.5 percent were considered in the screening analysis. Cost comparison of the 2.5 percent versus 3.5 percent maximum grade profiles along the Bakersfield-to-Sylmar alignment segment that reduced-grade options would significantly increase projected capital cost – by approximately $500 Million for the I-5 Alignment option. This capital cost increase would be offset by the operating benefits of lesser gradients, including power consumption reduction of 10 percent to 20 percent, as well as lower anticipated maintenance costs.

Assuming that tunnel air blast effects are addressed so that train speeds need not be reduced at portals, grade is not a significant factor in travel time over the Tehachapis. Travel times from Bakersfield-to-Sylmar are only marginally improved (by approximately one minute depending upon alignment option) by use of flatter gradients. This time savings is likely to be increased by higher speeds that may be realized due to fewer tunnel portal effects.

## 2.2 EVALUATION METHODOLOGY

As listed in Table 2.2-1, a number of key evaluation objectives and criteria were developed based on previous studies with enhancements that reflect the Authority's high-speed train performance goals and criteria described in Task 1.5.2. These objectives and criteria have been applied in the screening of high-speed train alignment and station options developed as part of this process. Each of the evaluation criteria is discussed in Chapter 4.0, Alignment and Station Evaluation.

**Table 2.2-1**
**High-Speed Rail Alignment/Station Evaluation Objectives and Criteria**

| Objective | Criteria |
|---|---|
| Maximize Ridership/Revenue Potential | ▪ Travel Time<br>▪ Length<br>▪ Population/Employment Catchment |
| Maximize Connectivity and Accessibility | ▪ Intermodal Connections |
| Minimize Operating and Capital Costs | ▪ Length<br>▪ Operational Issues<br>▪ Construction Issues<br>▪ Capital Cost<br>▪ Right-of-Way Issues/Cost |
| Maximize Compatibility with Existing and Planned Development | ▪ Land Use Compatibility and Conflicts<br>▪ Visual Quality Impacts |
| Minimize Impacts to Natural Resources | ▪ Water Resources<br>▪ Floodplain Impacts<br>▪ Threatened & Endangered Species Impacts |
| Minimize Impacts to Social and Economic Resources | ▪ Environmental Justice Impacts (Demographics)<br>▪ Farmland Impacts |
| Minimize Impacts to Cultural Resources | ▪ Cultural Resources Impacts<br>▪ Parks & Recreation/Wildlife Refuge Impacts |
| Maximize Avoidance of Areas with Geologic and Soils Constraints | ▪ Soils/Slope Constraints<br>▪ Seismic Constraints |
| Maximize Avoidance of Areas with Potential Hazardous Materials | ▪ Hazardous Materials/Waste Constraints |

The engineering and environmental methodologies and assumptions used in evaluating the high-speed train alignment and station options are described in detail in Task 1.5.2.

### 2.2.1 Engineering Evaluation Criteria

The engineering evaluation criteria focus on cost and travel time as primary indicators of engineering viability and ridership potential. Items such as capital costs and travel times have been quantified for each of the alignment and station options considered. Other engineering criteria such as operational, construction, and right of way issues are presented qualitatively.

The evaluation criteria presented are consistent with the criteria applied in the previous corridor evaluation study and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed train systems, and recommendations of VHS and maglev manufacturers.

A. BAKERSFIELD-TO-LOS ANGELES ENGINEERING METHODOLOGY VARIANCES

Travel Time

Travel time was calculated as express travel time from the Bakersfield Golden State Station to Los Angeles Union Station. Travel time calculations considered alignment design speeds and reflected acceleration times and 6 percent schedule recover time, consistent with the statewide criteria. Travel time data from the Sacramento to Bakersfield corridor was provided for three representative links from the Bakersfield Golden State station site to the three connection points to the Bakersfield-to-Los Angeles region. These connection points are located along I-5, in the area of Comanche Point and along SR-58, each at the base of the Tehachapi Mountains in the Central Valley. For the purposes of analysis, it was assumed that southbound trains departing from Bakersfield will have achieved full operating speed by the connection points. Travel times reflect maximum operating speeds of 220 mph (350 kph), subject to speed reductions on sustained grades. Speed losses were assumed to be consistent with the analysis prepared by DE Consult, showing decreases in top train speeds for various ICE trainsets **(Figure 2.2-1)** along sustained 3.5 percent gradients. The characteristics of the DPT400 trainset, the Germans' most advanced VHS technology, were used in calculating speeds. For simplicity, speed losses were assumed to be linear for grades up to 12 miles (20 km). None of the alignments studied includes individual sustained grades longer than 12 miles (20 km).

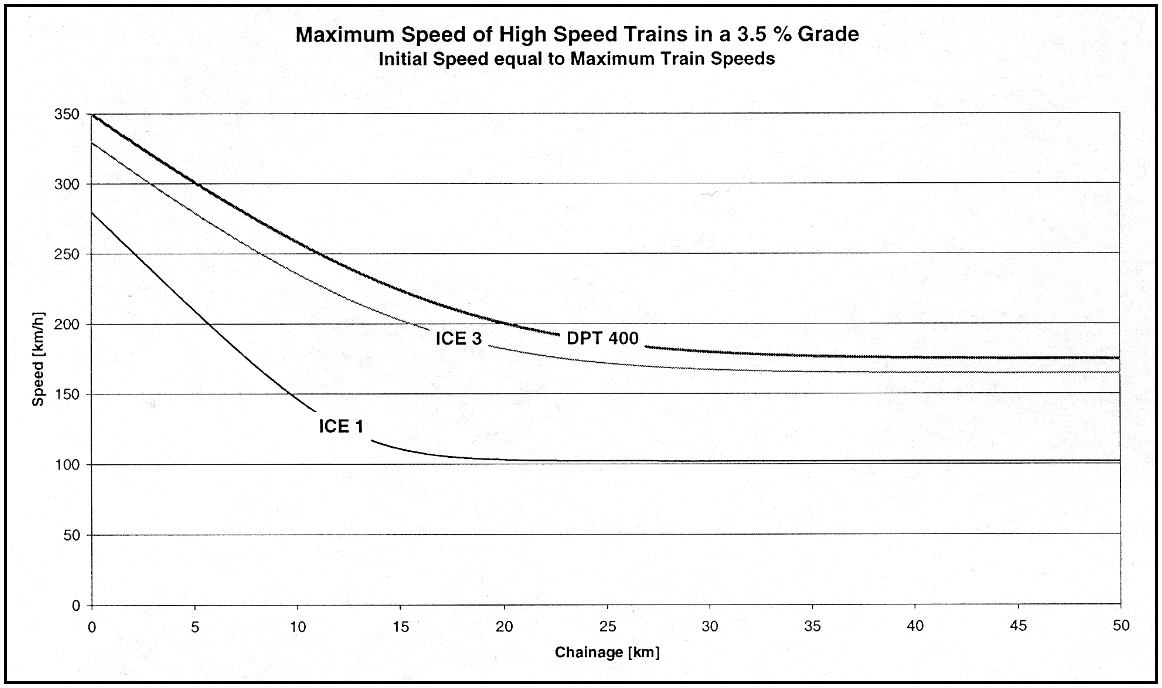



**Figure 2.2-1 – Projected Speed Losses on Sustained 3.5 percent Gradient**

For approaches into/out of LAUS, appropriate acceleration rates and times were considered, as set forth in the engineering criteria. Additionally, travel times considered the feasibility of achieving design speeds, given adjacent speed constraints. For example, where operating speeds were constrained at either end of a specific segment, travel times assume that trains would maintain a restricted speed through short unconstrained segments lying between constrained-speed areas, rather than quickly accelerating and decelerating.

Travel times were also calculated for the San Diego connection alternatives. Acceleration times and speeds were calculated, consistent with established engineering criteria and alignment constraints. This information was provided to the Los Angeles to San Diego teams for their use in evaluating alignment options within those corridors. Connection points to the San Diego alignments are as follows:

| | |
|---|---|
| Option 1 & 1A | Soto Street |
| Option 2 | Alameda Street |
| Option 3 & 3A | Soto Street |
| Option 4 | Soto Street |
| Option 5 | Soto Street |

Length

While alignments were evaluated based on measured length of segments, length was also a factor in evaluating certain station site options. Alignments were compared and rated against one another based on overall length. Because alignment approaches to downtown Los Angeles are highly dependent upon the proposed location of Los Angeles Union Station (LAUS), additional alignment length required to accommodate a particular station site was considered in developing the length ratings for station options.

Population/Employment Catchment

The amount of population and/or employment within a defined area surrounding potential station options was used as a surrogate for ridership potential. This measurement is only applicable for comparing station locations that are a significant distance apart. For station locations that were closely spaced (less than five miles apart), the population/employment data was calculated for only one of the closely spaced station sites. A catchment area of 20 miles was used for stations 20 miles or more apart. A catchment area of 10 miles was used for stations closer than 20 miles apart.

This information should be used to consider the relative effectiveness of the stations in attracting passengers on a regional or system-wide basis, or when potential station sites for a given area are spaced far apart.

Connectivity and Accessibility

The varied means and modes of access to station locations was inventoried. This includes freeways and their proximity to the station site, availability of direct access from freeways or arterial streets, other rail or transit systems, express busways, local bus service, shuttle bus service, proximity to airports, and pedestrian and bicycle access. Stations were given higher scores for having a greater number of and more efficient access and transfer options.

Operational Issues

Operating implications of alternatives were evaluated based on the potential safety, reliability, and flexibility that could be offered by the alignment alternative or station site option. Alignment and station alternatives that presented the fewest potential constraints to train movements were rated highest. Alignment ratings with respect to operational issues reflect a composite of ratings for Grade, Curvature, Tunnel Length, and Tunnel Portals.

**Operating Speeds**
Alignments were compared with respect to their ability to achieve and maintain 220 mph (350 kph) operating speed. Alignments that cannot provide for top speeds throughout their length were ranked less favorably.

**Grade**
Steep grades, particularly in close proximity to station sites, were considered negative operational conditions. Sustained grades can degrade train performance and increase operating and maintenance costs. Grades of 1 percent or less were considered the most favorable. Where alignments achieve gradients of up to 3.5 percent, a least favorable rating was made.

**Curvature**
Horizontal curvature of high-speed alignments allows them to avoid various constraints, including existing development and topography, thereby minimizing capital costs and reducing impacts. Conversely, curvature acts to constrain operations and increase operating costs. The presence of curves will limit the location of turnouts and crossovers, since these must be located on tangent sections of track, which are important to providing access to stations and to

allow for train meets (passing of trains) between stations. The use of small-radius curvature may also increase maintenance costs along the alignment due to uneven rail wear. The light weight of high-speed rolling stock; however, may make large-radius curves preferable to long tangent track by forcing the train against the rails and preventing “seeking” motion, where the train wanders from side to side, which increases rail wear. The most favorable ratings with respect to curvature were given the alignments with very large radius curves or near-straight alignments, those with fewer curves in close proximity to stations, and with the fewest number of minimum radii (4750 m.) curves at top speed. Alignments that included significant curvature or require radii below the top speed received the least favorable rating.

**Tunnel Length**

Provisions and procedures must be made for evacuation from long, deep tunnels. Tunnels must also be equipped with ventilation and life safety systems. Therefore, alignments with longer tunnels, which present safety concerns, generated a lesser rating for this evaluation factor. Where intermediate access along tunnels longer than 8 miles (13 km) could not be attained, an adjacent evacuation was also assumed. This third bore, while increasing construction risk and capital cost, somewhat offset safety concerns of longer tunnels.

**Tunnel Portals**

In addition to the total length of tunnels, the number of tunnel portals was considered in evaluating alignment alternatives. Individual tunnel portals present operational challenges that were considered in alignment ratings. High-speed train tunnels require accommodation at portals to diffuse air pressures during train entrance and exit. Portal characteristics will have implications on train performance, passenger comfort, noise and vibration impacts, and capital costs.

### Construction Issues

The generalized constructibility or ease of construction for the various alternatives was considered in the evaluation of alignments and stations. Factors considered included: site access, ability to use conventional construction methods, earthwork and structures.

**Site Access**

Ease of construction is influenced by the ability to access the alignment from existing public rights of way. Alignment reaches that are constrained by close development or are not accessible from existing roadways make construction more difficult, resulting in a lesser rating. Maintenance of traffic was considered a limitation of site access; adjacent vehicular traffic and adjacent railroad operations that would preclude unlimited construction access resulted in less favorable ratings for this factor.

**Construction Methods**

The ability to use conventional construction equipment was a significant factor considered in evaluating construction issues for the various alignment alternatives. The requirement for underground construction, where unforeseen conditions are likely to be encountered, resulted in less favorable ratings.

The construction of mountain tunnels is assumed to be accomplished with tunnel boring machines (TBMs). Once set in place, the typical TBM will produce approximately 1000 cubic meters of spoil per day. This can be severely and negatively impacted by the ripability of soils encountered. Additionally, TBM efficiency may be severely undermined where soil and rock conditions vary significantly along the tunnel length. As a result, lengthy tunneling and the presence of rock at deep excavations resulted in least favorable ratings for this evaluation factor.

As previously noted, mobilization of TBMs to each tunnel portal site is also a significant constructibility and cost issue. Access roads and power must be supplied to tunnel access point. Additionally, the relative ease of spoil removal is influenced by the number of tunnel portals and availability of spoil areas. A large number of remote portals, therefore, resulted in a least favorable rating with respect to construction methods.

**Earthwork**
The high-speed train project, particularly in the Bakersfield-to-Sylmar segment, would include substantial excavation and grading, yeilding significant earthwork quantities. While borrow is not considered to be an issue within the Bakersfield-to-Los Angeles region, the removal and disposal of spoil, particularly from tunnels, is a significant consideration. Alignments with high earthwork quantities present construction challenges that result in a less favorable rating.

**Structures**
“Special” aerial structures, which are assumed to span other structures or reach in excess of 20 meters above grade, will require special accommodation during construction. Those alignments with a significant amount of special aerial structures were given a least favorable rating with respect to this factor.

Capital Cost

Alignment alternatives were ranked according to calculated capital cost, using the cost estimating methodology and unit prices provided in the Alignment/Station Screening Methodology. Options with lower total capital costs were ranked most favorable and those with higher costs less favorable. In preparing capital cost estimates, minor deviations to the established cost estimating methodology were made, as described below.

**Earthwork and Related Items**
Earthwork quantities for the Tehachapi crossings (Bakersfield-to-Sylmar) were determined from earthwork cross-sections. Two-to-one side slopes and intermediate benches were assumed for cut and fill slopes. At this level of design, no retaining walls were assumed. For at-grade construction, excavation to 3.25 feet (1 meter) was assumed for roadbed construction. Any earthwork required for at-grade construction within existing rail corridors was neglected, as was landscaping/habitat restoration or erosion control. Drainage facilities cost was calculated as 5 percent of site preparation, earthwork, and imported borrow costs.

**Fencing**
Fencing was assumed along the entire length of the alignments, excluding tunnels and aerial structures.